# ON THE CLASSIFICATION OF THE CESTODE GENUS *MONIEZIA* (BLANCHARD 1891)

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The investigation, of which the present article is the outcome, was suggested to me by Professor Warrington Yorke, who kindly put all the material of the Liverpool School of Tropical Medicine at my disposal. I wish here to tender my thanks to him, and also to Mr. Southwell for allowing me to make use of his prepared slides, as well as for his friendly assistance and advice.

The museum collection contained material from cattle, sheep, and goats from Port Said, Malta, Accra, Bâle, and different localities in England. As most of this material was fragmentary and as there could thus be no certainty that the contents of any one bottle originally belonged to one worm only, it was decided to procure fresh material. This was obtained from the Liverpool Abattoirs during the months of May to September, 1923, and only entire worms were kept. All these were preserved and cleared in the same way, in order that so far as possible the differences due to preservation, etc., might be avoided.

It has recently become customary, when examining large cestodes, to select small portions from various positions of the strobila and to identify the species on the data so obtained (Sauter). This rough and ready method is very convenient and may be sufficient in old and established genera, where the differences between the various species are well-defined. But in the genus *Moniezia* it is apt to lead to confusion. The examination of entire worms—a most laborious

proceeding—enables one not only to see the variations present in different specimens, but also variations which may be present in any one worm. In this way, I have been able to show that several differences which were looked upon as specific may, and actually do occur in a single individual.

## HISTORICAL

Blanchard in 1891 created the genus *Moniezia* with the following diagnosis :—

'Corps lancéolé en avant, anneaux serrés, beaucoup plus larges que longs, avec deux pores sexués, opposés,'

and included in it the following eleven species :—

*M. alba,* Perroncito 1878
*M. benedeni,* Moniez 1874
*M. denticulata,* Rudolphi 1804
*M. expansa,* Rudolphi 1810
*M. festiva,* Rudolphi 1819
*M. goezei,* Baird 1853
*M. leuckarti,* Riehm 1881
*M. marmotae,* Fröhlich 1862
*M. neumanni,* Moniez 1891
*M. nullicollis,* Moniez 1891
*M. pectinata,* Göze 1782

Moniez (1891) included *T. ovilla,* Riv. 1878, and *Thysanosoma actinioides,* Diesing 1834, in this new genus.

Stiles and Hassall (1893) emended Blanchard's definition as follows :—

'Head without hooks ; segments generally broader than long and longer than thick ; end segments shewing a tendency to become longer and narrower. Two full sets of genital organs, with two uteri and two lateral pores in each segment. On the right side the vagina is ventral, cirrus dorsal ; on the left side vagina dorsal, cirrus ventral. Dorsal canal lies dorso-median of the ventral canal. Genital canals cross the longitudinal canals and nerves dorsally. Interproglottidal glands generally present. Calcareous bodies absent from parenchyma. Eggs with well-developed pyriform body.'

Type species *M. expansa* (Rudolphi 1810) Blanchard 1891.

Stiles and Hassall included in this genus eight species which fell into three groups :—

(*a*) *Planissima* group, characterized by the linear arrangement of the interproglottidal glands.

*M. planissima*
*M. benedeni*
*M. neumanni*

(*b*) *Expansa* group, characterized by the saccular arrangement of the interproglottidal glands.

*M. expansa*
*M. oblongiceps*
*M. trigonophora*

(*c*) *Denticulata* group, in which the interproglottidal glands are absent.

*M. denticulata*
*M. alba*

As *Moniezia* they include five of Blanchard's original species and further describe three new species. Later, Stiles classifies as *Cittotaenia* the double-pored leporine forms, which differ from *Moniezia* in the following particulars :—

'Vagina ventral to the cirrus-pouch on both sides of the segment; interproglottidal glands absent; generally one, but in some cases two, simple transverse tubular uteri in each segment; uterus generally possesses simple, proximal and distal diverticula. Eggs with a well-developed pyriform body, the horns of which are long, generally filamentous and cross each other. Type-species *Cittotaenia latissima*, Riehm 1881 = *Cittotaenia denticulata* (Rudolphi 1804), Stiles and Hassall 1896.'

In this genus Stiles includes four of Blanchard's original *Moniezia*, namely :—

*M. denticulata* = *Cittotaenia denticulata*
*M. goezei* = *Cittotaenia denticulata*
*M. marmotae* = *Cittotaenia marmotae*
*M. pectinata* = *Cittotaenia pectinata*

*M. nullicollis*. Stiles does not consider this to be a well-established species, as knowledge of its anatomical details is lacking.

*M. festiva*. He mentions this species as being recorded as a *Moniezia* by Blanchard. Nybelin (1917) has since re-examined Rudolphi's original specimen and has made it the type species of a new genus *Hepatotaenia*, closely allied to the genus *Cittotaenia*.

Fuhrmann (1902) placed the double-pored avian cestodes—the genus *Paronia* of Diamare 1900—into the genus *Moniezia*. They

were left here until 1918, when Fuhrmann accepted the genus *Paronia*. This genus differs from *Moniezia* in the arrangement of its genital ducts; in the structure and origin of its uteri, and in the absence of a pyriform apparatus in the egg.

Since the revision of the adult cestodes of cattle, sheep and allied animals by Stiles and Hassall, several new *Moniezia* have been described, namely :—

*M. rugosa* (Diesing 1850), Lühe 1895, in *Ateles hypoxanthus*.

*M. amphibia*, von Linstow 1901, in *Hippopotamus amphibius*.

*M. minima*, Marotel 1912
*M. triangularis*, Marotel 1913
*M. conjungens*, Sauter 1917
*M. latifrons*, Sauter 1917
*M. crassicollis*, Sauter 1917
*M. parva*, Sauter 1917
*M. pellucida*, Blei 1920
*M. translucida*, Jenkins 1923
*M. chappuisi*, Baer 1923

The question of the validity of these species will be considered below.

## GENERAL STRUCTURE OF THE GENUS *MONIEZIA*

The segments are usually very much broader than long (fig. 9), though worms may be met with in which the breadth may only be three times the length (figs. 6 and 7). These variations are attributable to the state of contraction or relaxation of the different sets of muscles, and to a certain degree they are specific. Thus, as a rule, *M. planissima* has a broader strobila than *M. expansa*. The actual shape of the segment, or the length of the complete strobila, cannot be considered as of specific value. I have been able to stretch a fragment of live worm to at least five times its original length, without damaging it. Also most worms undergo an appreciable amount of contraction when placed in weak formalin, and further contraction may take place when clearing in clove oil.

The length of the strobila also depends on the age of the worm; for instance, an individual which has but newly established itself will be short, and mature segments will be reached within a short

distance of the scolex. I have seen specimens of the *expansa* group, 30-50 cms. in length, in which the last segments were gravid. In older worms the strobila may be anything up to three metres long. In this case the difference between any two succeeding proglottides is not appreciable, and maturity will only be arrived at at a considerable distance from the head. I have seen several fragments, measuring 70 cms.-1 metre in length, in which all the proglottides were at the same stage of development.

The amount of overlapping is also dependent on the state of contraction of the various muscles. One individual may show broad proglottides with overlapping edges, where the longitudinal muscles have contracted, whereas a few inches further back the longitudinal muscles may be relaxed and the circular muscle-layer be contracted, giving the segment a longer, narrower appearance, with hardly any overlapping of the posterior edges.

The question of shape and size has here been gone into in detail, because these points have been taken to be of specific value.

All the authors are agreed that the shape of the head and the length of the neck are liable to show a great deal of variation. On the whole, the scolex and neck of the *expansa* group can be said to be long and slender, whereas in the *planissima* group they are squat and broad, even when in a fairly relaxed state. I have drawn several heads (figs. 1-5), all taken from typical *Moniezia expansa*, showing the shapes they may assume, according to the sets of muscles contracted. Fig. 3 resembles the head of *M. expansa* as drawn by Stiles and Hassall (1893), whereas fig. 5 corresponds with their drawing of *M. oblongiceps*.

The nervous, excretory and muscular systems are essentially the same throughout the genus (see Tower 1900, Zschokke 1888) so need not be dealt with here.

### The Expansa Group

In this group the cells of the interproglottidal glands are arranged around blind sacs. To this group have been ascribed *M. expansa*, *M. oblongiceps*, *M. trigonophora*, *M. minima*.

The interproglottidal glands are usually well-developed and stain readily. In material, however, which had been preserved for several years, I occasionally had great difficulty in making them take the stain at all. They were likewise often very difficult to see


Fig. 1.


Fig. 3.

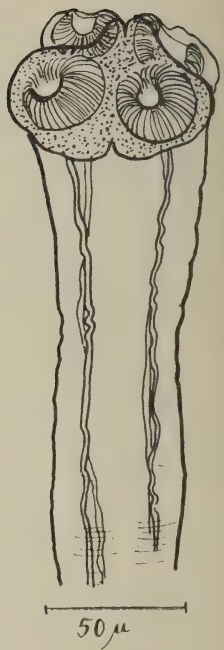


Fig. 4.

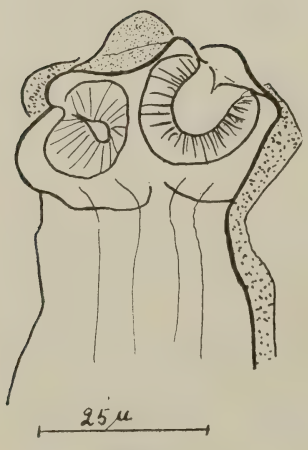


Fig. 2.

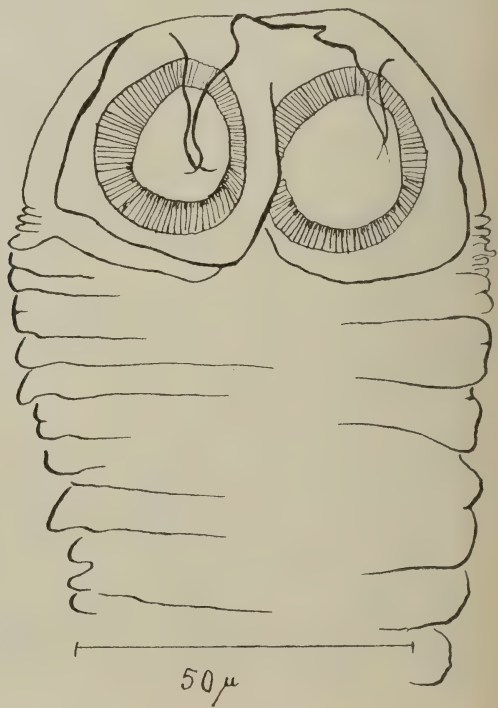


Fig. 5.

Figs. 1-5. Heads of typical specimens of *M. expansa*.

in strongly-contracted specimens. Nevertheless, a diligent search of the whole strobila never failed to reveal their presence. In relaxed specimens, where the glands were easily visible, they were seen to increase in number, in proportion to the width of the segment. In gravid segments they may be obscured by the number of eggs present (fig. 12). Among the numerous specimens examined, I found one worm, apparently normal in all respects, and in a relaxed condition, which showed some of its segments devoid of all traces of glands. After every seven or eight ordinary segments, one or two of these abnormal ones were interposed.

Stiles and Hassall give the smallest number of glands as twenty-five for *M. expansa*. I have seen many specimens of typical *M. expansa*, collected in this country, in which the number was much less. As few as seven glands may often be met with, and some mature segments may never have more than about fifteen. Thus the number of glands present and their prominence cannot be taken as of specific value.

The arrangement of the female genitalia is essentially the same in all the species described.

The arrangement of the testes, however, shows a certain amount of variation. In *M. trigonophora*, the testes are roughly arranged in two right-angled triangles; the base of the triangle is nearly parallel to the posterior edge of the segment; the perpendicular is parallel with the lateral margin; the hypothenuse runs from the antero-lateral portion to the posterior edge near the median line. These triangles never meet in the mid-line. In *M. expansa*, according to Stiles and Hassall, numerous testes are present, and they occupy the median line as well as the rest of the median field. According to Zschokke, the testes of *T. expansa* are arranged in two triangles, one each side of the segment, as is the case in *M. trigonophora*. Stiles and Hassall further remark that by far the greater number of segments of *M. expansa* examined by them did not present this relation, although in a few segments of this species, which were collected at Paris, the triangular arrangement of the testes is very distinct. In Rudolphi's specimens the testes are not visible.

My experience is that the testes in *M. expansa* may be roughly arranged in two broad triangles which usually meet in the mid-line (fig. 6), or in a continuous band thinning slightly towards the

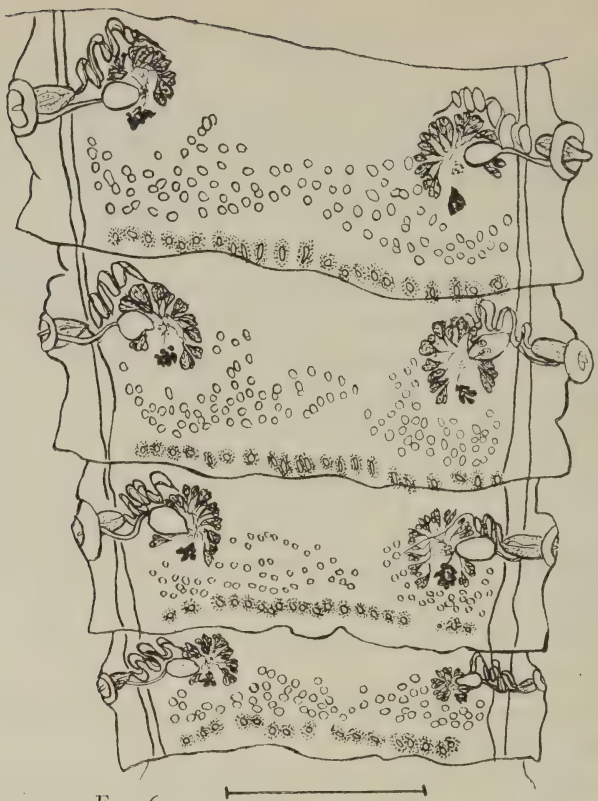


FIG. 6.

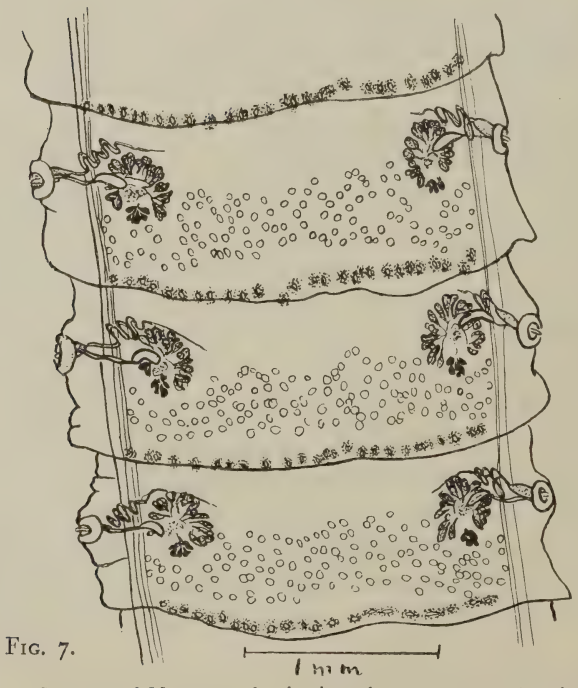


FIG. 7.

FIGS. 6 and 7. Segments of *M. expansa* showing irregular arrangement of testicular fields.

mid-line (fig. 7), or they may be as numerous in the median field as elsewhere (fig. 8). All three types may be found in one individual, or only one type may be present. On the whole, I am inclined to think that this question of arrangement also depends on the state of contraction of the segment. It can be readily conceived that Fig. 7 is Fig. 6 with the circular muscles slightly contracted, and that in Fig. 8 we have still further contraction of the circular muscles. As Child rightly points out, the arrangement of the reproductive organs may vary widely in correlation with the variation in form of the proglottid. There is also a variation in the number of testes in different segments of one strobila.

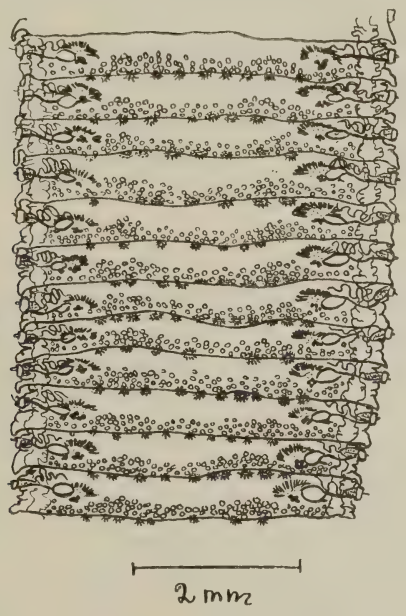


Fig. 8. Contracted segments of *M. expansa*, showing testes arranged in a continuous band.

*M. oblongiceps* agrees with *M. expansa* in all respects, except that the testes are smaller and less numerous. The description of this species is based on two entire strobila and one fragment. As both specimens are under one metre long and are gravid, it seems that we are dealing with a parasite newly established in the gut. The description, when regarded from this point of view, agrees with that of a young *M. expansa*. Thus *M. oblongiceps* must be considered as a synonym of *M. expansa*.

The characteristic features of *M. minima* are given as follows: gravid segments square (anneaux ovigères carrés); testes arranged in a continuous band. As pointed out above, the shape of the segments depends entirely on the amount of contraction present (figs. 6-8), and the arrangement of the testes shows a considerable amount of variation. Hence *M. minima* must be regarded as a variation of *M. expansa*.

The *expansa* group thus contains but two species: *M. expansa*, in which the testes are roughly arranged in a band stretching to the excretory vessels on either side, and *M. trigonophora*, in which the testes are arranged in two triangular fields that do not meet in the mid-line.

It is possible that forms intermediate between *M. trigonophora*, with its two triangles not meeting in the mid-line, and the variation of *M. expansa* as drawn in Fig. 6, may still be found. However, until further variations have been demonstrated, it is preferable to consider the two as separate species.

### The Planissima Group

In this group the cells of the interproglottidal glands are arranged in a line at the juncture of the segments. Ten species have been described which have this linear arrangement of the interproglottidal glands, namely :—

*M. benedeni* (Moniez 1879), R. Blanchard 1891
*M. neumanni*, Moniez 1891
*M. planissima*, Stiles and Hassall 1892
*M. triangularis*, Marotel 1913
*M. conjungens*, Sauter 1917
*M. latifrons*, Sauter 1917
*M. crassicollis*, Sauter 1917
*M. parva*, Sauter 1917
*M. pellucida*, Blei 1920
*M. translucida*, Jenkins 1923

The glands in this group have been described as short and ill-defined (*M. triangularis*), or large and distinct (*M. planissima*), or first linear and later arranged round three blind sacs (*M. conjungens*). These differences are more apparent than real, as the glands in any one strobila may vary a great deal in length. The dorsal gland may

be considerably longer than the ventral, or *vice versa*, or both may be approximately equal in length (fig. 9). Again, the linear gland may be broken up into smaller parts (fig. 9). I have never observed these cut-off portions to be arranged around blind sacs as described

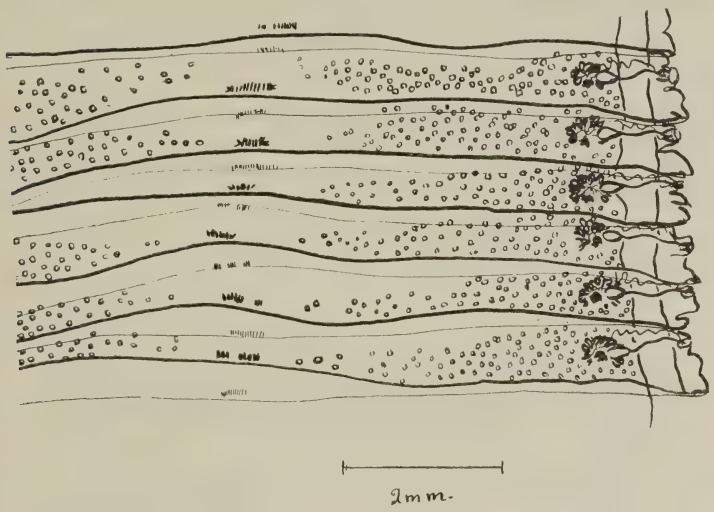


Fig. 9. Segments of *M. planissima*, showing testes arranged in two triangles; glands entire or broken.

by Sauter; on the contrary, the glandular cells always persist in their linear arrangement. In all the relaxed specimens examined, glands were discernible in each proglottid.

The testes in this group, as in the *expansa* group, show a great deal of variation in their arrangement. In the usual typical form they are arranged in two irregular triangles which may or may not meet in the mid-line (figs. 10 and 11), the two triangles may be some distance apart (fig. 9), or the testes may merge into one another and form a continuous band, stretching from the one longitudinal excretory vessel to the other (fig. 12). These differences may appear indiscriminately in young immature segments, in old segments, or in adjoining segments.

I could establish no constant relationship between the average width of the segment, the arrangement of the testes and the length of the gland or its tendency to break up into smaller portions. On the contrary, all the evidence goes to prove that each of these factors varied independently of the others. The different combina-

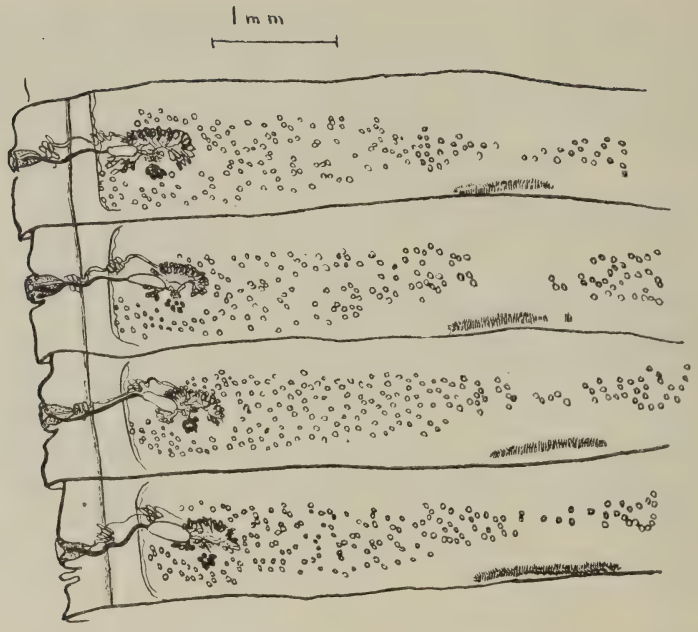


FIG. 10. *M. planissima*, showing irregular arrangement of testicular fields; glands entire or broken.

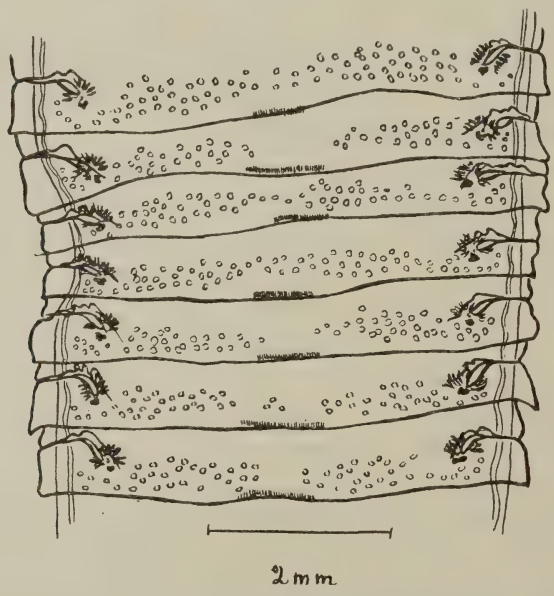


FIG. 11. *M. planissima*, showing irregular arrangement of testicular fields. In this strobila this irregular arrangement persists until maturity is reached. In later segments the glands are broken up.

tions possible would give the various species described; as, for example: small linear gland, testes in two triangles = *M. triangularis*; small linear gland, testes in a continuous band = *M. neumanni*; large linear gland, testes sometimes in two triangles and sometimes a continuous band = *M. planissima*; large gland, testes in a continuous band = *M. translucida*. Unfortunately, however, these arrangements cannot be considered as constituting separate species, as any number of intermediate forms are possible; they are rather to be looked upon as variations of *M. planissima*, with the other described species as links in the chain. In his account of

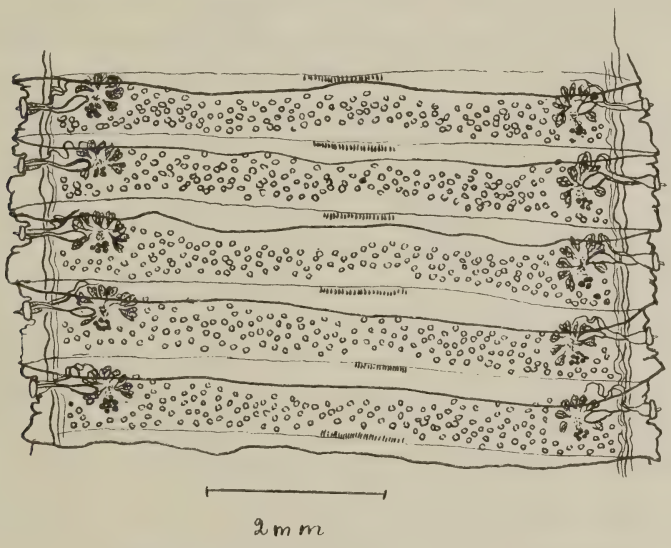


FIG. 12. *M. planissima*, showing testes arranged in a continuous band; glands entire or broken.

*M. conjungens*, Sauter (1917) describes the interproglottidal gland as first linear and later arranged around three blind sacs. As I have never seen this arrangement, but as the linear gland is often broken up into several smaller parts, I assume that this is what Sauter saw, although he draws them arranged round blind sacs.

The *planissima* group thus contains but one species, which will have to be designated *M. benedeni*, in which the head is comparatively large, the testes may be arranged in two triangular fields, or in a continuous band; and the proglottidal gland is linear, and of varying length.

THE ALBA GROUP

This group is based on the fact that its members have no interproglottidal gland. In the material put at my disposal by Mr. Southwell were several bottles labelled *M. alba*, the determination in each case having been based on the examination of a fragment taken from about the middle of the worm. On examination of the whole strobila, however, interproglottidal glands were invariably found under high magnifications. Most of these specimens were either much contracted and distorted, or had been kept in alcohol for a considerable length of time, so that they did not stain well.

With only the above evidence to support the theory, it would be unjustifiable to deny that there may be *Moniezia* without any glands at all, especially in view of the fact that I have seen a well-preserved specimen in which the glands were definitely absent in some of the segments. This absence of the interproglottidal glands may either be due to degeneration of the worm, or possibly to maceration of the material, or to some other cause. Until more work has been done on the presence and function of these glands, *M. alba* must be accepted as a valid species.

Baer (1923) described a new species, *M. chappuisi*, from an antelope, in which no glands were discernible. His description is based on a contracted specimen, and as it shows no essential differences from the description given for *M. alba*, it must be considered as synonymous with that species.

SPECIES INQUIRENDAE

*Moniezia rugosa* (Diesing 1850), Lühe 1895

Lühe 1895 re-examined Diesing's original specimen of *T. rugosa* from the monkey, *Ateles hypoxanthus*. He describes it as a typical *Moniezia*, but does not mention any glands. His oldest segments were not mature enough to enable him to describe the eggs.

If this is a true *Moniezia*, it will fall into the *Alba* group. The question of its validity can only be settled by further work on the parasites of *Ateles*.

*Moniezia amphibia*, v. Linstow 1901

This worm is reported from *Hippopotamus amphibius*, where it was present in large numbers. From the description and figures

given, it is difficult to decide whether it is a *Moniezia* without interproglottidal glands, or any other double-pored anoplocephalid. In the drawing of the egg, the horns of the pyriform apparatus may be interpreted as possessing a disc or as having their tips bent over.

Until the original material has been re-examined, this species will have to be considered as a *Moniezia*, of the *Alba* group.

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